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LIGA at SSLS

UV LIGA







































Energy loss per revolution [kW]	P[W/mrad 100mA] = 1.37 @ 1.3 GeV
	P[W/mrad 100mA] = 2.44 @ 1.5 GeV P[W/mrad 100mA] = 9.96 @ 1.5 GeV,
Characteristic energy [eV]	Ec = 1.6 keV @ 1.3 GeV
	Ec = 2.5 keV @ 1.5 GeV Ec = 10.5 keV @ 1.5 GeV, 7T
Vertical opening angle [mrad]	$\Psi = 0.3 - 0.4 mrad$























X-ray Mask – Membrane Materials

- Good X-ray and optical transmission
- Good mechanical stability, low internal stress
- Radiation resistant
- Compatible with established mask making processes and equipment
- Compatible with plating of Au absorber

=> Thin membranes from Silicon, Silicon Nitride, Titanium, Diamond

=> Low Z "sheets" from Graphite, Beryllium, and Silicon (UDXRL)

X-ray masks are important for a successful LIGA fabrication

X-ray Mask – Fabrication Process

Electron beam lithography in thin resist layers $(3-4 \mu m)$

Intermediate X-ray mask for 2-3 μm of Au, 0.1 - 0.2 μm details, rounding below 100 nm, vertical sidewalls

Electron beam lithography in thick resist layers (20 µm)

Working X-ray mask for up to 15 μ m of Au, no sub- μ m details (proximity effect), rounding ~3 μ m, vertical sidewalls

Optical lithography in thin resist layers (3-4 µm)

Intermediate X-ray mask for 2-3 μm of Au, ~0. 5 μm details, rounding ~1 μm , vertical sidewalls

Optical lithography in thick resist layers (20-80 µm)

Working X-ray mask for 15-50 µm of Au,....limits?

Smaller Size has its Price !

























Application of Thick PMMA Resist Solvent Bonding



• Potential for mass production



























LIGA-PMMA

PMMA (Poly-methylmethacrylate), is the most commonly used resist for deep x-ray lithography

- a positive resist
- good quality in accuracy and sidewall roughness
- extremely insensitive

PMMA: 500 µm Scan length: 6 cm Synchrotron at CAMD: 1.3 GeV, Storage ring current: 150 mA Exposure time: 6 hours

SU-8 Based Deep X-ray Lithography

SU-8 Photo Resist : **SU-8** has very high optical transparency above iline(360 nm), which makes it ideally suited for imaging near vertical sidewalls in very thick films.

SU-8 is negative resist and commercially available from MCC (MicroChem Corp., USA) or MRT (Micro Resist Technology, Germany)

It consists of three parts: **Resin: EPON SU-8 resin Solvent: GBL Initiator: a triaryl sulfonium salt**





































SU-8 Deep X-ray Lithography/LIGA Application

- Fabrication of micro rotary engine housing

Background

"Mechanical engineers at UC Berkeley's Combustion Processes Laboratories have built the world's smallest rotary internal combustion engine."

- Lab Notes, UC Berkeley, v.1, n.1, 2001



Mini-engine World's smallest rotary internal combustion engine. (UC Berkeley photo)























LIGA: Electroforming and Molding



µGalv plant (M-O-T) with one process circuit dedicated to gold electroplating for x-ray masks, one Cu and one Ni (Ni-alloy) process circuit.



Ni plated microstructures before polishing



Nickel microstructure/ mold insert



HEX 01 hot embossing systems from Jenoptik-Mikrotechnik.





Fabrication and Inspection by means of X-ray





LIMIN L beamline is used for the fabrication of high aspect ratio micro/nanostructures by X-ray lithography/LIGA technology **PCIT beamline** is used for the analysis of hollow high aspect-ratio microstructures by phase contrast imaging and tomography.

